Synopsis

It has been noticed that the need for total knee replacement surgery is increasing for Asian region. A total knee replacement is a permanent surgical solution for a patient having debilitating pain in knee joint suffering from arthritis. In this surgery, knee joint is replaced with components made up of bio-compatible materials after which the patient can resume the normal day to day activities.

Western population has bigger build compared to Asian population. Most of the total knee replacement prosthesis are designed for western population. When these total knee prosthesis are used for Asian population, they cause a mismatch leading to various clinical complications such as reduced range of motion and pain. The studies have been limited to clinical complications caused by the mismatch. To address this limitation, current study is aimed to find the mechanical implications such as stress distribution, maximum stresses, maximum displacements etc., caused by mismatch of total knee replacement components with knee. A surgeon selects total knee components for a patient based on some critical dimensions of femur and tibia bone of knee. In addition, a method to accurately calculate these dimensions of the femur and tibia bone of a real knee was developed in the current study. This method calculated the points of curvature greater than a threshold (decided based on the radius of the curvature) found out using the formula of curvature. Further, the highest point was calculated based on maximum height from a line drawn between initial and final point within the captured points, also the extreme points were calculated based on the sign change in slope of points within the captured points, giving multiple points on the boundary of bones extracted in an MRI image of a patient. The distance between two selected farthest points, out of these points, in specific direction was the basis for selection of the TKR components.

Total knee replacement components were modeled in Geomagic Studio 12 software, bones were modeled in Rhinoceros 5 software, assembly of bones and total knee replacements components was done in Solidworks 2013 software, the finite element model of the assembly was developed in Hypermesh 11 software and, the stress analysis and post processing was done in ABAQUS 6.13 software. A static, implicit non linear analysis was performed. Simulations were performed for two conditions: at standing (0^o of flexion) and at hyper-flexed (120^o of flexion). In order to figure out if there

were any mechanical implications of mismatch, the full model of assembly consisting of femur, tibia and fibula bones assembled with total knee replacement components, and the reduced model consisting of only total knee replacement components were simulated separately, results of which have been discussed in the current thesis. In this work, the effect of change of length of ligaments at 120^{o} of flexion in detail was also studied. This study brought out various outcomes of contact mechanics and kinematics between the components of total knee replacement prosthesis.